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RESEARCH PAPER

A Hybrid Grounded Theory, Fuzzy DEMATEL and ISM Method for Assessment of Sustainability Criteria for Project Portfolio Selection Problems

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Abstract
In this paper, a set of sustainability criteria is introduced and a hybrid Multi Criteria Decision Making (MCDM) method is performed in order to identify and classify a set of criteria for selecting a project portfolio. Proposed criteria based on fuzzy DEMATEL technique in an uncertain environment are assessed to determine the relation among all of the criteria. Moreover, ISM method is used to level the proposed criteria which are effective in the process of selecting the project or not. The results obtained from the proposed method demonstrates that profit, cost, soil, atmosphere, energy, waste and risk are the most effective criteria in selecting project portfolio, especially in construction project selection. Furthermore, environmental issues play an important role in the selection of project portfolio while social issues are not as much significant as others. Technical requirement, water, security, and public utility are less effective criteria in selecting project portfolio. Besides, biodiversity, social integration, and responsibility criteria are the most effected criteria in selecting project portfolio.

Keywords: project selection, sustainability, DEMATEL, ISM, construction projects.

1. Introduction

The implementation of new projects over the last few decades has provided organizations the competitive advantages necessary for success in their respective markets. Despite the commonality of new project implementation in organizations, there are still numerous accounts of either project failure or project instability across various industries (Allen et al., 2014). Project selection is widely recognized as an important task due to limited project management resources, the opportunity cost among different projects, and other company investments (Archer & Ghasemzadeh, 1999). Due to the increased use and potential payback of projects, it is critical for companies to select the best projects to support organizational strategy. One way to select the best projects is through the use of Project Portfolio Selection (PPS).

Sustainability has commanded global attention, largely due to the reality that adverse environmental impact is increasingly a matter of concern. Many researchers have shown that construction projects cause many disadvantages for the environment (Griffith et al., 2005; Ma & Kremer, 2015; Okudan Kremer et al., 2013). According to the US Environmental Protection Agency (US EPA) (2011,101), sustainability is the effort to “create and maintain conditions, under which humans and nature can exist in productive harmony, and that permit fulfilling the social, economic, and other requirements of present and future generations.”

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World Summit (2005) summarized sustainability as an integration of social, economic, and environmental factors in its official report. The three pillars of sustainability in business are people, profit, and planet, which correspond to social, economic, and environment perspectives (Daneshpour, 2016). In order to avoid some of these negative effects, sustainability becomes a goal. With the advent of Agenda 21 at the 1992 Earth Summit, the necessity of applying sustainability arose in a strategic level in urban areas. This scheme shows the need for constructing a set of sustainability criteria that result in urban development as well as other targets determined by organizations.

Nowadays, more than 70 tools and techniques are used to classify and assess construction projects based on a set of sustainability criteria (Fernández-Sánchez & Rodríguez-López, 2010). These criteria have also caused significant problems, including uncertainty and subjectivity during the selection of criteria, criteria and dimensions (Hueting & Reijnders, 2004), the domination of environmental criteria during the assessment of construction projects, the shortage of stakeholder's participation during the project life cycle, and minimizing the great number of criteria present in the existing system of criteria.

Many studies have addressed detrimental effects of construction projects on the environment (Shen & Tam, 2002; Tam et al., 2002). These criteria comprise noise pollution, waste generation, energy consumption, water discharge, dust and gas emission, misuse of water resources, land misuse, and consumption of non-renewable natural resources (Chen et al., 2005; Shen et al., 2005).

As these social, economic, and environmental challenges get more complex, some actions such as fundamental changes in management, defining activities with higher adaptability, and innovative actions should be done (Pope et al., 2004). Numerous studies have addressed project management and sustainability context separately, whereas few studies have focused on the intersection between these two contexts. According to Gimenez et al. (2012) and Kleindorfer et al. (2005), sustainability comprise economic, social and environmental issues, which integrate to create a logical use of resources in present and expose a routine life for future generations.

Some studies have tried to integrate these two topics (Anning, 2009; Bernhardi et al., 2000; Bodea et al., 2010; Jones, 2006; Martens et al., 2013; Mulder & Brent, 2006; Sánchez & López, 2010; Turlea et al., 2010), while further research projects are needed to extend new tools, techniques and methodologies (Thomson et al., 2011), which could be applied on project management problems in order to evaluate an aspect of sustainability in projects and organizations (Deakin et al., 2002).

Themes of sustainability and project management are converged in some recent studies, which is necessary for current business context, coupled with the increasing importance of both issues in the area of business. This paper intends to clarify the context of sustainability in project management by the introduction of a set of criteria as criteria for project portfolio selection.

According to Bochini et al. (2014), project management can be used to integrate sustainability criteria in projects. In the context of project management, sustainability attracts the interest of professionals and academics. Sustainability concept is divided into economics, social and environmental sub criteria which form *triple bottom line*. It is obvious that sustainability is a major criterion, although both social and environmental aspects cannot be integrated in projects (Fernandez-Sánchez, 2015).

Due to remarkable impacts of construction projects on sustainability development, several management methods and approaches are developed as a guidance for managers in order to attain better sustainability performance throughout their projects. Shen et al. (2005) proposed a novel framework for evaluating sustainability performance of construction projects by creating a performance checklist to understand the significant criteria affecting the sustainability of construction projects. Fernández-Sánchez and Rodríguez-López (2010) developed a methodology to identify sustainability criteria for civil engineering projects which is applied in a case study on infrastructure projects in Spain. Martens and Carvalho (2018) reviewed some important sustainability criteria as the prospect of project managers. These mentioned criteria are given in Table 1. Zolfani et al. (2018) assessed construction projects based on sustainability criteria by means of MCDM techniques for hotels. A hybrid Multiple Criteria Decision Making (MCDM) model is proposed. Step-wise Weight Assessment Ratio Analysis (SWARA) and Complex proportional assessment (COPRAS) compose a unified framework. Hatefi and Tamošaitienė (2018) evaluated construction projects by considering sustainability criteria, using a hybrid fuzzy AHP and GRA method. Hendiani and Bagherpour (2019) extended an index for evaluating social sustainability of construction projects utilizing fuzzy logic. Goel et al. (2019) integrated sustainability criteria in construction project management as a literature review of past two decades. Erdogan et al. (2019) utilized MCDM techniques for selecting construction projects by considering sustainability criteria. Camgöz-Akdağ (2020) put forward an MCDM method to evaluate project selection qualifications in a Big-Four company located in Turkey, which leads the projects in Turkey, and prioritized the project selection criteria under fuzziness in order to give in a perspective about a project's main criteria and sub-criteria and to focus on which qualifications should be focused. Singh and Pant (2020) provided an overview of some popular weighing methods applicable to the MCDM process and also showed the performance of these methods through a case study. Ma et al. (2020) used fuzzy MCDM methods for selecting a project portfolio by considering sustainability criteria. The main purpose of this study was to target project selection from the perspective of sustainability in an uncertain decision-making environment. To achieve this purpose, a fuzzy logic model based on the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) approach was used to incorporate sustainability under uncertainty to obtain the most sustainable solution. Alyamani and Long (2020) applied fuzzy analytic hierarchy process (FAHP) in sustainable project selection. Some of the most common characteristics or criteria used in evaluating sustainable projects include novelty, uncertainty, skill and experience, technology information transfer, and project cost. Prioritizing these criteria based on relative importance helps project managers and decision makers identify elements that require additional attention, better allocate resources, and improve the selection process when evaluating different sustainable project alternatives. Paredes and Herrera (2020) applied a Multi-Criteria Decision Making based on sustainability factors to road projects.

In this paper, a set of criteria is introduced and a hybrid MCDM method was adopted in order to identify and classify a set of criteria for selecting a project portfolio and assess the proposed criteria based on fuzzy DEMATEL technique in an uncertain environment in order to determine the relation among all of the criteria. Besides, ISM method was used in order to level the proposed criteria that are effective in the process of selecting the project. All the possible criteria for selecting construction projects are illustrated in Table 1.

The main contribution of the paper is introducing a complete set of sustainability criteria which are used in evaluating project portfolio selection, especially construction projects. Moreover, the importance of each factor is determined by a hybrid decision-making method under uncertainty. In this case, fuzzy logic is applied. The use of ISM method for leveling the proposed criteria is another innovation of this paper. The results of this paper can be used by every study that needs a complete and precise set of criteria in the field of sustainability. Moreover, the most important and effective criteria can be concluded by the result of this paper.

Table 1. Criteria Effective on Project Portfolio Selection

Effective criteria on portfolio selection	**Martens & Carvalho (2017)**	**Seiw(2016)**	**Wang et al. (2014)**	**Fernández-Sánchez & Rodríguez-(López (2010**	**Xing et al. (2009)**
Project revenue		*			*
Benefit of society	*	*			
profit		*			
Operating cash flow		*			
Proportion of project cost funded			*		*
Aid from government or organization		*			
Disaster risk		*			
Maintenance cost					*
Direct cost				*	
Indirect cost				*	
Cost of society				*	
Life cycle cost			*	*	*
Cost incurred to users				*	
Local economy				*	
Constructability				*	
Durability				*	
Functionality				*	
Ecological value				*	
Erosion and sedimentation				*	
Soil consumption				*	
Water saving	*	*		*	*
Water consumption	*	*		*	*
Pollution	*	*		*	*
Protection of water resources	*	*		*	
Ventilation				*	
Noise				*	*
GHG emission		*		*	*
Particulate and dust emission		*		*	
NOx, CO2, and SO emission				*	
Ozone emission		*			
Energy consumption		*		*	
Renewable energy				*	
Saving energy	*	*		*	
Energy efficiency	*	*	*	*	
Impacts on the environment				*	
Protection of flora and fauna				*	
Barrier effects				*	
Waste management			*		*
Waste production			*		*
Mitigating the effects of floods and draughts				*	
Adaption and vulnerability to climate changes				*	
Infrastructure control				*	
Safety and health of workers		*	*	*	*
User security		*		*	

Table 1.

Effective criteria on portfolio selection	Martens & Carvalho (2017)	Seiw(2016)	Wang et al. (2014)	Fernández-Sánchez & Rodríguez-(López (2010	Xing et al. (2009)
Impact on the global community			*	*	
Security of the infrastructure				*	*
Number of injuries and fatalities		*			
Project declared of general interest	*				
Satisfaction of society	*			*	*
Happiness				*	
Job creation					
Local workers during the implementation of project				*	
Raising levels of training and information				*	
Environmental campaign				*	
Integration into the society	*			*	
Corporate social responsibility of the sponsor				*	
Environment and sustainable awareness				*	
Necessity and urgency of the work				*	

This paper is structured in 5 sections. After the introduction, in section 2 research methodology and the proposed criteria for selecting a project portfolio are presented. Then the discussion on the results is followed by section 3. In section 4, some implications of the research are represented. Finally, concluding remarks and some suggestions for further studies are presented in section 5.

2. Research Methodology

Qualitative-quantitative mixed methods approach has been used in this research. Grounded theory (GT) has been applied as qualitative and fuzzy DEMATEL method as quantitative methods. These two methods will be explained in more detailed in the following section.

We sought to investigate the criteria affective on selecting project portfolio, and the aim of this study was to find the more important criteria. We considered experts' ideas and comments and used qualitative data obtained from Grounded theory. Experts were some project managers in the field of construction projects.

After acquiring the conceptual model questionnaire study, criteria affecting the portfolio selection based on the technical implementation DEMATEL was designed in two phases, determining the weight and priority issues and the quantitative analysis of the data. The data collected in the quantitative phase of research was a pairwise comparison questionnaire designed by experts. In this study, a questionnaire was distributed among 14 experts familiar with project management. Using literature, criteria affecting the portfolio selection were extracted from the previous studies. Then, a relation matrix between the concept and interactive matrix was created to categorize these criteria. Criteria affecting the portfolio selection were identified according to the literature, and after sorting, were categorized using the DEMATEL-ISM method.

Figure 1. Research Framework

2.1. Grounded Theory

Grounded theory is a qualitative methodology for developing theories from collected data through stages entitled open coding, axial coding, and selective coding. This method provides a comprehensive theoretical explanation about a specific phenomenon (Glaser & Strauss, 2017). The aim of GT method is to give importance to inductive approach in studies because it looks for creating a theory through gathered data. Qualitative approaches are applied for gathering informative data about one phenomena and theory is extracted from data. Since this strategy is one kind of qualitative research, the research problem is not exactly expressed in the form of dependent and independent variables, but only the main research question is set forth in the discussion. Key topics in this strategy are codes, concepts, and categories (both primary and secondary) (Pandit, 1996). The strategy of growth conceptualization theory or grounded theory method was introduced first by Glaser and Strauss (2017). The main steps of grounded theory are as follows:

- **Open coding:** naming concepts which indicate certain incidents and other samples of the phenomena.
- **Axial coding:** a procedure through which data are compared with each other constantly in order to determine open links between openly coded data.
- **Selective coding:** it refers to the process of selecting from the results of axial category, its systematic link to other categories, valuing their relations, and inserting categories that need more confirmation and development.

To conduct grounded theory, first a research question is expressed and then informative data is gathered and analyzed for responding to the question. Data obtained from informative sources (interview, documents investigations, etc.) evolves in the table form. Therefore, first the key points of data are attained and a code is determined for each point and then through comparing codes, several codes referring to a common aspect of investigated phenomenon makes one common concept. In the next step, several concepts are manifested in one category and several categories are manifested in the form of a theory. To strengthen the obtained theory, the differences and similarities of that theory to other studies will be investigated through literature review. The more the components of the theory are confirmed by other studies, the stronger that theory will be (Strauss & Kurbin, 1998). In grounded theory, an active part of the research process is validation. In our study, after referring to literature and considering the opinion of a group of experts, effective criteria for selecting project portfolio were extracted, and by applying grounded theory, these criteria were categorized into 14 sections. These 14 sections were then categorized into 3 groups (namely economic, environmental, and social). These are represented in Tables 2, 3 and 4 below.

Table 1. Economic Criteria

Economic	
Profit	Project revenue
	Society benefit
	Operating cash flow
	Proportion of project cost funded
	Aid from government or organization
Cost	Disaster risk (replacement cost)
	Maintenance cost
	Direct cost
	Indirect cost
	Cost of society
	Life cycle cost
	Cost incurred to users
	Local economy
Technical requirements	Constructability
	Durability
	Functionality

Table 2. Environmental criteria

Environmental	
Soil	Ecological value
	Erosion and sedimentation
	consumption
Water	Saving
	Consumption
	Pollution
	Protection of water resources
Atmosphere	Ventilation
	Noise
	GHG emission
	Particulate and dust emission
	NO_x, CO_2, and SO emission
	Ozone emission
Energy	Consumption
	Renewable
	Saving
	efficiency
Biodiversity	Impacts on the environment
	Protection of flora and fauna
	Obstructing effects of the projects
Waste	Management
	production
Risk	Mitigating the effects of floods and draughts
	Adaption and vulnerability to climate changes
	Infrastructure control

Table 3. Social Criteria

Social	
Security	Safety and health of workers User security Impact on the global community Security of the infrastructure Number of injuries and fatalities
Public utility	Project declared for general interest Satisfaction of society Happiness Job creation
Social integration	Local workers during the implementation of project Raising levels of training and information Environmental campaign Integration into the society
Responsibility	Corporate social responsibility of the sponsor Environment and sustainable awareness Necessity and urgency of the work

2.2. Fuzzy Logic

Since the paper focuses on sustainability and MCDM, we first introduce them briefly. Calabrese et al. (2016) proposed a fuzzy Analytic Hierarchy Process (AHP) method to support materiality assessment in sustainability reporting. Another method in the field of fuzzy logic was recommended by Khishtandar et al. (2017), which suggested a MCDM framework for sustainability assessment of bioenergy production technologies in terms of hesitant fuzzy linguistic sets. By considering these papers, a fuzzy set and other relationships in this area are introduced in the following description.

A fuzzy set is a collection of elements with membership degree (μ) belonging to that set. This membership function for each *x* number in the form of triangular is defined as:

$$u_{\tilde{A}}(x)=\begin{cases}(x-l)/(m-l), l\leq x\leq m; l\neq m\\(x-r)/(m-r), m\leq x\leq r; m\neq r\\0 \qquad\qquad\qquad\quad ,Otherwise\end{cases}. \tag{1}$$

2.3. Fuzzy DEMATEL Method

In many papers, DEMATEL method has been applied for selection problems and combined with other prioritization methods for selecting or weighting alternatives. In this paper, DEMATEL method is summarized in the following steps. To use DEMATEL method, experts' opinion is required, and their comments contain verbal expressions which are ambiguous. In order to integrate and clarify them, these phrases should be converted to fuzzy numbers. To solve this problem, Lin and Wu (2008) proposed Fuzzy DEMATEL in an uncertain environment.

Step 1: compute matrix **A** which is average initial direct-relation matrix. To construct this matrix, some experts are asked to have a pairwise comparison between criteria which represents the impact of relation between them.

$$\mathbf{A}=\begin{pmatrix} 0 & \dots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 0 \end{pmatrix}. \tag{2}$$

To produce the average initial direct-relation matrix in order to measure the relationship between different criteria, five scales are represented in Table 5:

Table 4. Fuzzy Number According to Linguistic Variable

Linguistic variable	Fuzzy number
No influence	(0,0,0,0.25)
Very low influence	(0,0,0.25,0.5)
low influence	(0,0.25,0.5,0.75)
High influence	(0.5,0.75,1)
Very High influence	(0.75,1,1)

Step 2: Compute matrix **Z,** which is normalization of initial direct-relation matrix. According to literature, the normalization coefficient is:

$$\lambda = Max(Max\sum_{j=1}^{p} a_{ij}, Max\sum_{i=1}^{p} a_{ij}). \tag{3}$$

$$\mathbf{Z}=\lambda^{-1}\mathbf{A}. \tag{4}$$

Step 3: Compute matrix **T** which is criteria total-influence matrix and is computed with Equation (5):

$$\mathbf{T}=\lim(\mathbf{Z}+\mathbf{Z}^2+...+\mathbf{Z}^k)=\mathbf{Z}(\mathbf{I}-\mathbf{Z})^{-1}. \tag{5}$$

Step 4: By using t_{ij} values, the sum of each row (D_i) and each column (R_j) can be computed as:

$$D_i=\sum_{j=1}^{p} t_{ij},\ \ (i=1,2,...,p), \tag{6}$$

and

$$R_j=\sum_{i=1}^{p} t_{ij},\ \ (j=1,2,...,p). \tag{7}$$

The sum of each row (D_i) represents the level of penetration and effectiveness level of criteria i and the sum of each column (R_j) demonstrates the level of permeability and the influence level of criteria i. Hence, values of (D_i+R_j) and (D_i-R_j) are computed as threshold values and demonstrate the casual relation among criteria.

2.4. ISM Method

ISM analyzes the relationship between indices by decomposing metrics at several different levels. ISM can be used to analyze the relationship between the characteristics of several variables that are defined for a problem. ISM methodology has quantitative limitations, and the identification of relationships between variables usually depends on the company which is studied by the decision maker. Therefore judgments of the variables can affect the final results. Designing interpretative structural model can be used to analyzed complex problems as abstract levels and make decision making more effective, easier, and more efficient. This model evaluates the effect of each variable on other variables. Using ISM method can be a wise choice to gain perspective insights in the system (Warfield, 1974).

2.4.1. Build Structural Self-Interaction Matrix (SSIM)

For each pair of criteria, experts are asked about the relationship between the two criteria, and five levels of 0, 1, 2, 3, 4 (corresponding to *no impact*, *very low, low, high,* and *very high* levels) were used for scoring in the questionnaire as a guide in order to represents the relationship between the two criteria *i* and *j*. According to Warfield (1974), we use the following symptoms: V, A, X, O.

V: only criterion *i* has impacts on criterion *j*.
A: criterion *i* has no impact on criterion *j* but criterion *j* has impact on criterion *i*.
X: both criterion *i* and *j* have impacts on each other.
O: there isn't any relation between the two criteria.

2.4.2. Developing Reachability Matrix

Here we change Structural Self-Interaction Matrix into a binary matrix according to some laws and call it Initial Reachability Matrix.

The rules of changing Structural Self-Interaction Matrix into Developing Reachability Matrix are:

- If the intersection of criteria (i, j) were **V** in SSIM, the intersection of (i, j) in reachability matrix would be equal to 1 and intersection of criteria (i, j) would be equal to 0.
- If the intersection of criteria (i, j) were **A** in SSIM, the intersection of (i, j) in reachability matrix would be equal to 0 and intersection of criteria (i, j) would be equal to 1.
- If the intersection of criteria (i, j) were **X** in SSIM, the intersection of (i, j) in reachability matrix would be equal to 1 and intersection of criteria (i, j) would be equal to 1.
- If the intersection of criteria (i, j) were **O** in SSIM, the intersection of (i, j) in reachability matrix would be equal to 0 and intersection of criteria (i, j) would be equal to 0.

This way, the Primary Reachability Matrix is formed, because if criterion '*a*' and criterion '*b*' have a relation and criterion '*b*' and criterion '*c*' have a relation as well, criterion '*a*' and '*c*' have a relation, too.

2.4.3. Leveling Effective Criteria

What we mean by a level in the ISM model is a position a criterion is located in. The higher the impact of a criterion on other criteria, the lower its position is in the ISM model. In ISM model, the impression is defined from bottom to top.

Leveling criteria is done in a way that each criterion with the same set of reachability and intersection will be located in the first level so that the mentioned criteria will be omitted from the set of criteria and the process is repeated for other criteria to level all the criteria.

ISM considers cause and effect relationships and DEMATEL determines the difference of these cause and effect criteria and compute the intensity of interactive and effective relationship among criteria and the intensity and strength of relationships.

If we only pay attention to the cause and effect relationships, the importance of criteria and different levels of real criteria will be ignored. On the other hand, if we just pay attention to the importance of criteria, we may reach an improper importance for all the criteria. Therefore, we integrate ISM and DEMATEL method.

3. Results

Each criteria indicated some sub criteria, and based on these criteria, a 14*14 pairwise comparison matrix was adjusted as a questionnaire with guidance and sub-criteria for each of the criteria. This questionnaire was given to experts and the obtained data were used as the elements of direct relationship matrix, and the impact of the relationship between them was clearly scrutinized. In this study, we used a five-point Likert scale as a guidance of scoring criteria for experts. According to the questionnaire N (no influence), VL (very low influence), L (low influence), H (high influence), and VH (very high influence) were the guidance for scoring the criteria. After gathering data by filling the questionnaire by experts, DEMATEL method was applied in order to find the cause-and-effect relationship among criteria, and the presence or absence of the final relationship between the two criteria was determined by MATLAB software and the judgment of majority of experts.

After coding and determining linguistic variables, the first step of fuzzy DEMATEL (**T),** which is tracing initial direct-relation matrix, needed to be performed. After this step, fuzzy numbers equivalent to linguistic variables were substituted in the table and then they were converted to crisp numbers with a de-fuzzy operation. Table 4 shows how hard these criteria affected each other.

Table 5. Intensity Effectiveness in Algorithm

Criteria	**Profit**	**Cost**	**Technical requirement**	**Soil**	**Water**	**Atmosphere**	**Energy**	**Biodiversity**	**Waste**	**Risk**	**Security**	**Public utility**	**Social integration**	**Responsibility**
Profit	0.062	0.1066	0.1028	0.1014	0.1008	0.0741	0.0948	0.1463	0.0858	0.1148	0.1077	0.1092	0.1458	0.1611
Cost	0.1222	0.084	0.1125	0.1116	0.1104	0.0994	0.1191	0.1585	0.127	0.1358	0.1169	0.1186	0.1425	0.1741
Technical requirement	0.0709	0.1139	0.0587	0.0743	0.092	0.0673	0.0698	0.0879	0.0945	0.0732	0.0815	0.1295	0.1346	0.1353
Soil	0.0763	0.0885	0.1185	0.0656	0.1163	0.0725	0.0748	0.1422	0.1014	0.0779	0.1232	0.125	0.1439	0.1591
Water	0.0633	0.0877	0.068	0.067	0.0491	0.0604	0.063	0.0952	0.0688	0.0656	0.0716	0.0727	0.1261	0.1237
Atmosphere	0.0716	0.0815	0.0963	0.095	0.0944	0.0501	0.088	0.1376	0.0784	0.0724	0.1007	0.1022	0.1246	0.1517
Energy	0.0922	0.1018	0.0994	0.0976	0.0975	0.0879	0.0566	0.1284	0.0814	0.0765	0.1037	0.1053	0.1288	0.156
Biodiversity	0.0638	0.072	0.0709	0.1035	0.0688	0.0594	0.0611	0.0631	0.0858	0.0631	0.0912	0.0918	0.079	0.1251
Waste	0.1183	0.1292	0.127	0.1381	0.1253	0.1119	0.0817	0.1424	0.0739	0.1017	0.1139	0.1164	0.1094	0.1704
Risk	0.1164	0.1394	0.1062	0.1051	0.1042	0.0935	0.0972	0.1515	0.1047	0.0666	0.1104	0.112	0.1199	0.1529
Security	0.0662	0.1094	0.1064	0.069	0.0699	0.0617	0.0647	0.0814	0.0714	0.0672	0.0573	0.0943	0.0994	0.1276
Public utility	0.0651	0.0914	0.0717	0.0691	0.0685	0.0603	0.0624	0.0972	0.0864	0.0646	0.1222	0.0574	0.0791	0.1261
Social integration	0.075	0.0848	0.0812	0.0793	0.079	0.1051	0.1064	0.0944	0.112	0.1215	0.1012	0.1019	0.0743	0.14
Responsibility	0.1203	0.1321	0.1284	0.1259	0.1261	0.0816	0.1011	0.1426	0.1265	0.1052	0.1326	0.1345	0.1426	0.114

The second step of DEMATEL method is applied on the former table. Based on this relationship, first the maximum value of the sum of each row in the table above was calculated and the resulting value was divided by all numbers of the table. After normalizing initial direct-relation matrix, we calculated final matrix (T) by applying the third step of DEMATEL method.

In the next step, the fourth step of DEMATEL technique was completed and the sum of rows (D) and columns (R) as well as D + R and D-R were calculated. The outcome of this stage is shown in the Table 6.

In Figure 2, which is obtained from MATLAB software, components based on two criteria “the importance” and “relationship” were determined, with areas above the horizontal axis representing effective criteria and areas located below horizontal axis representing bonding criteria.

Table 6. DEMATEL Output

Criteria	Profit	Cost	Technical requirement	Soil	Water	Atmosphere	Energy	Biodiversity	Waste	Risk	Security	Public utility	Social integration	Responsibility
D	0.4658	0.6039	0.3163	0.4478	0.1883	0.3535	0.3883	0.1888	0.5509	0.4993	0.2176	0.2100	0.3517	0.5655
R	0.2410	0.3910	0.3392	0.3208	0.3116	0.1814	0.2150	0.5777	0.3102	0.2725	0.4013	0.4230	0.5566	0.8065
D+R	0.7069	0.9949	0.6555	0.7685	0.4999	0.5348	0.6033	0.7665	0.8612	0.7718	0.6189	0.6329	0.9083	1.3719
D-R	0.2248	0.2129	-0.0229	0.1270	-0.1233	0.1721	0.1733	-0.3889	0.2407	0.2269	-0.1837	-0.2130	-0.2049	-0.2409

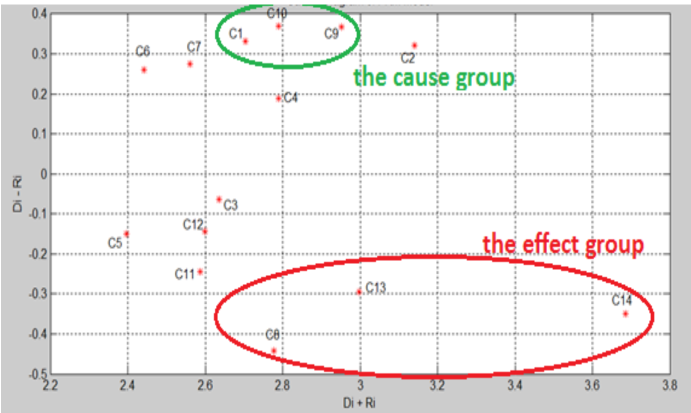

Figure 2. Output of DEMATEL Model by MATLAB

In Figure 2, obtained from MATLAB, components are determined based on the importance and relationship. C_1, C_9 and C_{10} (namely profit, waste, and risk) are the highest components in Figure 2. These are the most effective ones among all criteria, which are called the cause group of criteria. C_8 and C_{14} (namely biodiversity and responsibility) are considered as the most effected criteria for selecting a project portfolio. These are called the effect group of criteria. C_9 indicates two sub-criteria (namely waste management and waste production), and C_{10} is comprised of three sub-criteria, i.e., mitigating the effects of floods and draughts, adaption and vulnerability to climate changes, and infrastructure control. This means that those who filled the questionnaire as experts of project management are concerned about environmental issue since both of the above mentioned criteria belong to the environmental set of criteria in sustainability issue. C_1 contains sub-criteria such as project revenue, benefit of society, operating cash flow, and proportion of project cost funded. It is obvious that one of the most important criteria that should be highlighted in projects is cost and profit. Every project-based organization first concentrates on the estimated profit and cost of each project besides other constraints and limitations. C_8 indicates three sub-criteria, namely impacts on the environment, protection of flora and fauna, and obstructing effects of the projects. Although this criterion is a subset of environmental issue, there is not as much emphasis on it as other criteria due to the less probability for such events. C_{14} includes three sub-criteria, namely corporate social responsibility of the sponsor, environment and sustainable awareness, and necessity and urgency of the work. We can hardly ever observe such criteria in construction projects, as is the case with this study: as the results show, it cannot be found among the effective criteria. In Figure 2, the locations of components are determined by two criteria which are the axis of the figure. The horizontal axis shows the importance of criteria and the vertical axis represents relationship criteria; components that are placed in the positive half of the figure illustrate the influence of these criteria that are causal and the most effective criteria. Moreover, the criteria that are located in negative half of the figure demonstrate the effect of the rest of the criteria on these criteria influence and the criteria in the figure placed at a lower level due to project portfolio selection criteria (which are the most important ones).

3.1. Leveling Criteria By ISM

For leveling, prioritizing, and determining the cause and effect relationship among the criteria, ISM method was utilized. As mentioned in the research methodology, the structural self-interaction matrix was first built, followed by the Initial Reachability Matrix. The results can be observed in Table 6.

Table 8. Initial Reachability Matrix

Criteria	Profit	Cost	Technical requirement	Soil	Water	Atmosphere	Energy	Biodiversity	waste	Risk	Security	Public utility	Social integration	Responsibility
Profit	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Cost	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Technical requirement	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Atmosphere	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Energy	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Biodiversity	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Waste	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Risk	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Security	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Public utility	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Social integration	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Responsibility	0	0	0	0	0	0	0	1	0	0	0	0	1	0

After obtaining structural self-interaction matrix, developing reachability matrix and final matrix (T) can be calculated through the method mentioned in the research methodology. In this matrix, direct and indirect relationships among elements are determined. The results of final reachability matrix can be seen in Table .

Table 9. Final Reachability Matrix

Criteria	Profit	Cost	Technical requirement	Soil	Water	Atmosphere	Energy	Biodiversity	Waste	Risk	Security	Public utility	Social integration	Responsibility
Profit	1	0	0	0	0	0	0	1	0	0	0	0	1	1
Cost	0	1	0	0	0	0	0	1	0	0	0	0	1	1
Technical requirement	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Soil	0	0	0	1	0	0	0	1	0	0	0	0	1	1
Water	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Atmosphere	0	0	0	0	0	1	0	1	0	0	0	0	1	1
Energy	0	0	0	0	0	0	1	1	0	0	0	0	1	1
Biodiversity	0	0	0	0	0	0	0	1	0	0	0	0	0	0
waste	0	0	0	0	0	0	0	1	1	0	0	0	1	1
Risk	0	0	0	0	0	0	0	1	0	1	0	0	1	1
Security	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Public utility	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Social integration	0	0	0	0	0	0	0	1	0	0	0	0	1	1
Responsibility	0	0	0	0	0	0	0	1	0	0	0	0	1	1

3.2. ISM-DEMATEL Method for Determining Effective Criteria

The scheme of ISM method obtained from criteria, which shows that the lower the criteria in the pattern of ISM method, the higher impact on the other criterion. After leveling all the criteria, we can draw the ISM flowchart that contains all criteria and relationships among them.

According to direct and indirect relationship among criteria obtained from ISM method, the intensity of influence in each criterion is available in Table 4. To avoid the bustle in the Figure, just some of the values in the table can be observed in Figure 3.

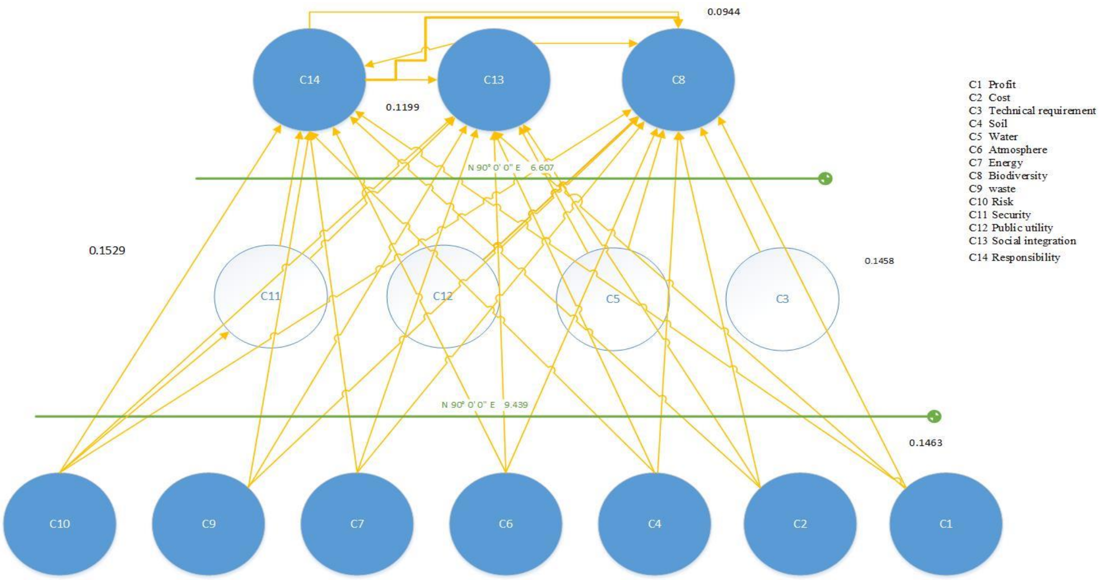

Figure 3. The ISM Scheme

In Figure 3, all of the criteria are shown in three levels. The most effective criteria are located in the lowest level. These criteria are C_1, C_2, C_4, C_6, C_7, $C_{9,}$ and $C_{10,}$ which are namely profit, cost, soil, atmosphere, energy, waste, and risk, respectively. These are the most effective criteria in project portfolio selection, especially construction projects based on the opinion of experts in project management. As we know, the economic issue in project management is one of the most considerable criteria. C_1 and C_2 (profit and cost) are such criteria which are located in economic area. C_4, C_6, C_7, $C_{9,}$ and C_{10} are about environmental areas. This illustrates that environmental issues play an important role in the project portfolio selection while social issues are not as much significant as others. In the second level, there are four criteria C_3, C_5, $C_{11,}$ and $C_{12,}$ which are namely technical requirement, water, security, and public utility, respectively. These criteria are the least effective criteria in selecting projects. As we consider construction projects, these criteria rarely have any impact on the mentioned projects. The last level in the figure contains three criteria C_8, $C_{13,}$ and $C_{14,}$ which are namely biodiversity, social integration, and responsibility. These are called the most effected criteria in selecting projects.

According to the numerical results obtained from this paper and the results of papers in this field, we can compare our finding with the previous studies in this area. These results will help project managers and decision makers identify selection criteria with higher weights of importance. Given that the selection criteria chosen for this research are not limited to the evaluation of a specific type of sustainable projects or a specific location, they can be used to evaluate different types of sustainable projects in different environments and locations. For instance, Alyamani and Long (2020) used the fuzzy analytic hierarchy process (FAHP) approach in which fuzzy numbers are utilized to realistically represent human judgment to rank the different project criteria based on relative importance and impact on sustainable projects. The results from this study demonstrated that the most important criterion in sustainable project selection is cost, followed by novelty and uncertainty as the second and third most important criteria, respectively. The two least important criteria out of the total of five criteria examined in this research were the skill and experience and technology information transfer. As we know, economic issue in project management is one of the most considerable criteria. The results obtained from this paper also claimed that profit and cost play an important role in project portfolio selection. Moreover, some criteria such as technical requirement, water, security, and public utility were found to be the least important ones in project portfolio selection.

4. Implications of the Research

Project portfolio management can be a good tool to help increase the efficiency and effectiveness of an organization. Project evaluation is important in the organization, especially when we are aware that most organizations are involved in this process such that even a significant portion of their revenue comes from their projects. On the other hand, by superficially examining the projects of these organizations, it can be understood that a large number of projects have been stopped due to the lack of access to facilities and resources or have stopped in the final stages as a result of incongruence with the organization’s goals. The main tools for implementing the strategies of project-based organizations, which include the selection and proper implementation of projects, play an important role in the success of organizations. In other words, project selection is in line with the organization’s strategies and ensures that the allocated resources are used effectively and play a key role in achieving the organization’s strategic goals. Considering uncertainty brings the situation closer to reality and provides a more accurate answer than the certain case. In other words, it greatly reduces the probability of fault in decision making, which is one of the main goals of project-oriented organizations, and helps project managers choose the best portfolio of projects. This decision is made in a situation that puts the sustainability of the system at its highest level. Among the criteria of system sustainability, we can mention the environmental conditions, which are not taken into account and unfortunately have irreversible effects on the environment.

5. Conclusions and Future Researches

One of the most significant problems is to select a set of criteria for sustainability that can be applied in project management for project selection issue. In this paper, a set of sustainability criteria were introduced by utilizing literature review as mentioned in the introduction. Then, a hybrid decision making method for analyzing and prioritizing these criteria by pairwise comparison in an uncertain fuzzy environment was applied. Construction projects and the identification of a set of criteria for selecting such projects were considered in this paper. As it was expected, about 66.66 percent of economic criteria were found to be the effective criteria in selecting project portfolio. Moreover, 71.42 percent of environmental criteria were shown to be effective in the selection of project portfolio, while no social criterion was found to have influence in this process. According to the related literature, further studies can apply these criteria to a project portfolio selection problem through either a MCDM approach or a mathematical modeling. Furthermore, other methods can be applied to the existing set of criteria in this study for weighting them such as lexicographic method, which is a mathematical modelling that considers uncertainty by interval data. Finally, other issues could be merged with sustainability in order to select the optimal project portfolio by considering different aspects such as resilience factors.

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